No. 747,341

ISSUED Nov. 29, 1966
CLASS 154-123

CANADIAN PATENT

PRESSURE-SENSITIVE ADHESIVE TAPE

Gordon W. Engdahl and Theodore Buchholtz, Saint Paul, Minnesota, U.S.A.

Granted to Minnesota Mining and Manufacturing Company, Saint Paul, Minnesota, U.S.A.

— Urethane foam/PSA
— Method of manufacture
— foam cast right on PSA or
a "prime" coated PSA.
PSA being on liner
— NO UV or EB Thermal process.

APPLICATION No. 871,233
FILED Mar. 19, 1963
PRIORITY DATE Apr. 18, 1962 (188,479) U.S.A.

No. OF CLAIMS 2

This invention relates to a novel double-coated foam-layer pressure-sensitive adhesive mounting tape which can be used for quickly and durably fastening rigid weighty articles to walls and other vertical or sloping surfaces, and to ceilings and other down-facing surfaces, as well as for other purposes.

The tape comprises a soft viscoelastic foam layer that is approximately 1/16 to 1/4 inch (1.6 to 6.4 mm.) thick, continuously covered on each side by a thin stretchy integral flat-surfaced skin to which is united a thin continuous flat shiny-smooth viscoelastic aggressively-tacky pressure-sensitive adhesive coating having a permanent hyper shear strength. In the complete tape article as manufactured and sold, each of the tacky adhesive tape faces is covered by a removable liner which provides a shiny-smooth release (anti-stick) surface in continuous adherent contact therewith. The tape is soft and flexible and can be conveniently supplied in roll form with a single interwound liner strip serving to cover and protect both faces of the tacky double-coated tape. See the accompanying drawing.

The combination of physical structure properties of this tacky adhesive tape is such that rigid weighty articles can be durably mounted on walls (including ceramic, masonry and plaster walls) by merely pressing strips of the tape on the back of the article and then pressing the article in position against the wall. The viscoelastic compression and conformation characteristics of the tape permit of establishing intimate long-lasting adhesive contact with the opposed article and wall surfaces even if rough and non-parallel, to thereby provide a durable resilient semi-rigid mounting of the article.

The pressure-sensitive adhesive coating that is employed is of a type which is aggressively tacky in its normal dry state, and it has a "permanent" hyper shear strength characteristic, by which it is meant that the adhesive is long-aging and will not soften or turn pasty upon prolonged contact with wall surfaces

and will maintain a highly cohesive and adhesive state. The shear strength is of a higher order of magnitude than has been characteristic of many adhesives which have been employed in conventional pressure-sensitive tapes. The adhesive coating has a high peel adhesion strength. The combination of viscoelastic cohesive and adhesive properties imparts to the foam tape an exceptionally high bonding strength adhesion value to enable it to perform as a mounting tape on vertical surfaces and strongly resist both shear and peel types of failure. The shiny-smooth and quick-stick properties of the continuous adhesive coating, which is stretchy and is firmly united to and supported by a flat-surfaced stretchy skin film, also contribute importantly to the establishment of a high bonding strength. Liquid or low-molecular-weight plasticizers which would impair the cohesive strength of the adhesive, or bleed into a wall surface upon prolonged contact with the tape, are avoided. The inclusion of pigments and other fillers which would impair the quick-stick or cohesive properties of the adhesive are avoided. We prefer to make use of adhesive coatings which consist essentially of a water-insoluble non-softening aggressively-tacky viscoelastic cross-linked polymer, although coatings of equivalent adhesive material having the requisite properties can be used since it is the physical nature of the adhesive coating that is important in the tape structure. Certain cross-linked acrylate copolymers have been found to be excellent for this usage and are presently preferred.

This highly flexible tape is resilient, compressible and recoverable, stretchable and retractable. It has an elastic compressibility modulus in a range which we have found to be highly advantageous. It is highly conformable to irregular or rough surfaces which it is pressed against, so that intimate surface-to-surface contacting and bonding thereto can be effectuated. The tape as a whole has sufficient "give" and resilient

deformability to intimately link together the opposed surfaces of the article and the wall or other base surface, despite lack of smoothness and parallelism, and to resist removal of the mounted article. In fact, roughness of the wall surface under these conditions is advantageous in that mechanical restraint is combined with adhesive restraint in resisting downward slippage of the tape on the wall. The foam layer is viscoelastic; and its "viscous" or "lossy" characteristic is advantageous in developing a strong permanent bond of maximum contact area between the tape and a rough or irregular surface against which it is pressed. The foam layer does not have the quick snap-back characteristics possessed by highly elastic rubber foams, which would tend to pull the tacky adhesive surface away from valley points that are only lightly touched when the tape is initially pressed against the surface.

It has been found that certain viscoelastic polyurethane foam layers are admirably adapted for present usage, both technically and economically. These have a bulk density in the range of 5 to 20 lbs. per cubic foot (0.08 to 0.32 grams per cc.) and in preferred tape products the foam density has been in the range of approximately 12 to 16 lbs. per cubic foot (0.19 to 0.26 grams per cc.). Other properties will be designated later on. The use of equivalent foam materials having the requisite physical properties is contemplated.

12 to 16 lb ft density

Note

It is the combination of the foregoing factors in a unitary tape structure which we have discovered to be responsible for the utility of the tape as a means for mounting and durably holding rigid weighty articles, and which distinguishes it from double-coated foam-layer adhesive tapes which lack adequate general utility in this field of use. These critical factors will be discussed in further detail as the description progresses.

A desired length of tape and protective liner can be unwound and readily severed by finger tearing, or by cutting with

scissors or pocket knife, to provide a piece of desired length. One or more pieces of tape (of appropriate length and number, depending upon the article) are pressed against the back of the article which is to be mounted, the liner strips are peeled off, and the article is then pressed in position against the base surface and thereby immediately united to it.

This mounting procedure is thus seen to be a very simple one that requires no special skill and no tools. As an illustration of the advantages of this procedure consider the following situation: A salesman for paper towels and dispensers, having made a sale, can himself quickly mount a towel dispenser on a washroom wall even if it is a masonry or tiled wall. The cost and delay of a workman are avoided and there is no occasion to drill holes or otherwise mar the wall. The dispenser can be removed if later desired, as by using a blade to cut through the tape, the residue on the wall being removed with the aid of a solvent if this is necessary. This mode of installation will facilitate the making of his sale because it avoids installation expense and delay.

There are many situations in which the tape of this invention can be employed to advantage both by artisans and by "do-it-yourself" people. In addition to dispensers and racks of various kinds, mention may be made of mirrors, pictures and plaques, wall and ceiling panels and moldings, wall telephones and telephone outlet boxes, thermostats, wall clocks and various kinds of meters, as further illustrations. Articles can be mounted on metal tanks and metal panels without puncturing, weakening or marring them.

Tape thickness
Advantage

A tape having a foam layer thickness of 1/16 inch (1.6 mm.) can be used for mounting articles on a wide variety of wall surfaces, including metal or wood panels and plaster, whether or not painted or lacquered, and marble. Tape having a foam layer thickness of 1/8 inch (3.2 mm.) is more versatile and

can be used on almost all types of walls, including tile and concrete walls. A foam layer thickness of 1/4 inch (6.4 mm.) is needed only for special situations, as where long lengths of tape are used for bonding large plywood panels to brick or concrete block walls. A tape width of 1 inch (25 mm.) is convenient for general usage.

The amount of tape needed for mounting a given article in any particular location depends upon the circumstances, but a useful general rule of thumb found applicable for wall mounting is to use at least about 4 square inches of tape per pound of weight of the article (corresponding to 60 sq. cm. per kilogram). In general, a strip of tape is positioned near the top of the article so as to hold the top edge close to the wall, and strips are usually also applied along the sides so as to prevent tilting or swinging and provide additional bonding and support. A strip of tape is used near the bottom in the case of paper towel dispensers so as to resist the pulling force when towels are removed. A single patch of tape may suffice in the use of a small light article. The thinness and resiliency relationship in the foam layer prevents appreciable sagging action and also resists peeling action tending to strip the tape from the wall. Yet the rubbery foam layer has enough softness, resiliency and "give" to avoid undue rigidity and to take up and distribute applied stresses in such manner as to enable the tape to provide a truly amazing holding power.

Need some give

The present tape permits of a semi-rigid resilient connection between the mounted article and the base. The mounted article will not wiggle or jiggle and it has a solid secure feel when pushed or pulled. A person pulling out a paper towel from a dispenser will not be made to feel that it is insecurely mounted. A properly bonded article cannot be easily pulled or yanked off. Mounted articles are relatively safe from petty vandalism efforts. Indeed, the impression of solid and secure

mounting tends to minimize petty vandalism temptations. The extraordinary holding power of the interposed tape is due to its location and to the combination of factors inherent in the total adhesive tape structure, the component elements coacting in such a way as to tend to resist all types of stresses whether due to dead gravity load or to other applied forces of constant, intermittent or sudden nature. However, a feature of the present tape is that it permits of mounting an article so that it can be removed, if later desired, by exerting a prolonged and forceful prying action which will gradually bring about a progressive splitting of the foam layer.

An advantage of using the present type of tape is that the mounted article is secured to the wall or other base by an interposed viscoelastic foam layer structure which isolates the article and tends to cushion it from vibrations and shocks occurring in the base member. This is of particular value when the article is fastened to a thin metal or other rigid panel, such as a panel of an airplane, motor boat, truck, powered appliance, air duct, etc., and especially so if the article includes a delicate mechanism as in the case of a clock or a meter. The "lossy" characteristic of the foam layer enables it to absorb and dissipate vibratory shear stresses induced by vibrations of the panel, the tape providing a viscoelastic coupling. The tape also provides thermal and electrical insulation between the article and the base.

Conventional double-coated pressure-sensitive adhesive tapes having a paper, film or cloth element coated with adhesive, cannot be used for durably mounting rigid weighty articles, even when the present type of adhesive is used, thus proving the essentiality of the foam layer in the present structure. On the other hand, most foam sheeting cannot be employed for present purposes, even when having an integral skin surfacing which carries the present type of adhesive. The present type of foam

layer is ineffective unless combined with the present type of adhesive coating. The previously described utility of the present tape depends upon a critical combination of physical structural characteristics which has been indicated in general terms above and will be described in further detail later on. It is recognized that the general concept of a pressure-sensitive adhesive mounting sheet or tape having a spongy rubbery layer with adhesive on both faces, has long been known to the art (thus see U. S. patent No. 2,292,024 issued Aug. 4, 1942). But so far as we are aware, no product of the present type, or capable of practical general usage for the same purposes, had been known to the trade prior to our invention.

Although the novel and useful tape product of this invention has particular unique properties for the mounting usages previously indicated, it can also be usefully employed for other fastening, holding and mounting applications. Thus it can be used for mounting flexible sheet or strip articles to obtain a durable tenacious bonding not possible with conventional double-coated adhesive tapes. An example is a flexible molded flat-based conduit attached to a baseboard or wall for carrying electric cords. It can be used for securing delicate components of electronic equipment in place on the top of a base surface, with the advantage of providing electrical, thermal and vibration isolation.

The present product may also be supplied in unwound flat strip or sheet form, protected on both faces by removable liners. Such sheets can be die cut to desired configurations.

A manufacturer may supply a ready-to-mount article with one or more pieces of the adhesive tape already adhered in place, so that the user need only remove the protective liner and mount the article by pressing it into position.

In the accompanying diagrammatic drawing:

Fig. 1 shows a roll of the double-coated foam-layer

pressure-sensitive adhesive tape 1, protected on both faces by the interwound removable liner strip 2.

Fig. 2 is an edge view of a piece of the adhesive tape article after removal from the roll (dimensions have been exaggerated in the interest of clarity). The soft viscoelastic foam layer 3 is continuously covered on each side by the thin stretchy flat-surfaced skins 4 and 5 to which are united the flat shiny-smooth pressure-sensitive adhesive coatings 6 and 7, corresponding to the complete double-coated tape 1 of Fig. 1. The interwound liner strip 2 of Fig. 1 now provides a removable liner strip 8 in adherent contact with one face of the adhesive tape, permitting the piece of tape to be pressed against the back of an article which is to be mounted, without contaminating the surface of the adhesive with oily or dirty material which may be on the fingers used in pressing. This protective liner strip may then be easily peeled off when the article is to be pressed into mounting position on a wall or other surface. The liner strip has shiny-smooth release surfaces on each side, since in the wound roll it serves to cover both faces of the aggressively-tacky adhesive tape and it maintains the shiny-smooth state thereof; and it permits the tape to be readily unwound from the roll with the liner strip remaining in adherent contact with the back of the tape as a protective covering. The tacky adhesive tape adheres to the anti-stick surfaces of the liner strip with sufficient force to maintain the roll structure and prevent spontaneous uncoiling or unwinding.

This tape structure may include a thin stretchy intermediate coating located between each pressure-sensitive adhesive coating and the skin of the foam layer and which firmly unites them. This intermediate coating may be included to provide a priming or barrier or other function which may be desired. It is to be considered as a sub-element of a composite flat-surfaced skin that covers and is unified with the cellular layer structure,

and to which the adhesive coating is united. The intermediate coating permits of controlling the total thickness and strength of the functional skin element. This expedient is optional but it facilitates the manufacturing procedure and has other advantages as will presently be pointed out in more detail.

Forming Process ✓x

The foam layer is preferably manufactured by a continuous process in which it is formed between a pair of horizontally moving webs, the lower one being supported on flat bed plates and the upper one resting upon the layer of the foam-producing mixture that is introduced between the webs, and being carried along with it as a cover sheet as the layer foams and expands and then sets and cures to its final state, with intermediate compression to provide a denser and thinner layer. The webs provide smooth impermeable surfaces in contact with the foaming layer so that a thin flat-surfaced skin surface is formed on each side of the foam layer, having the same composition and stretchy nature as the walls of the internal cellular structure.

Foaming right on adhesive!

This expedient permits of using as the pair of foam-confining webs, pressure-sensitive adhesive-coated liner sheets (which may or may not have the aforesaid intermediate coatings united to the adhesive coatings) which will provide the combination of releasable liners and double-coated adhesive coatings embodied in the foam-layer product. Foaming against the pressure-sensitive adhesive coatings (or intermediate coatings) results in foam layer skins which are tenaciously united to the adhesive coatings. In this manner a double-coated pressure-sensitive adhesive foam layer in releasable adherent contact with the liners is provided automatically during continuous production of the foam layer. One liner is ultimately stripped off when the product is used in providing tape wound in a roll with a single liner strip as illustrated in Fig. 1.

In the above manufacturing procedure the liners are provided with pressure-sensitive adhesive coatings in a

preliminary operation; the adhesive coating solution or dispersion being coated upon the shiny-smooth release surface so as to result in a dried adhesive coating having a shiny-smooth face surface in releasable adherent contact therewith. A polyethylene film, or a dense smooth paper carrying a polyethylene film or coating, may be used as a liner sheet. Preferably the liner is a dense calendered paper treated with an anti-stick heat-cured silicone resin, which is insoluble in the volatile vehicle of the adhesive coating solution and retains its low adherency to the contacting adhesive even when subjected to heating. A liner paper which is to be retained in the wound-roll product must of course have a release coating on both sides.

Use of non-tacky "primer" on PSA prior to applying foam

When an intermediate coating is employed, as mentioned above, it is coated upon the pressure-sensitive adhesive coating carried by the liner sheet and thus becomes firmly united to the adhesive coating. When the coated liner is used in producing the foam layer, the foam skin is formed against this intermediate coating and tenaciously bonds to it so as to result in a composite skin layer united to the adhesive coating. This procedure has the incidental advantage that the tacky-surfaced liner sheet is masked over by a non-tacky coating, which permits of easier storage and handling of the liner sheet preparatory to its use in fabricating the foam layer product.

The foregoing manufacturing procedure permits of conveniently curing or cross-linking the pressure-sensitive adhesive polymer when the adhesive is in its dry coated state upon the liner sheet, and during the foam layer production stage. A cross-linking agent included in the foam producing mixture, or generated during the foam-making reaction, can migrate into the adhesive coating against which the foam layer is formed, and curing of the adhesive layer can be effected simultaneously with heating of the foam layer. This same result can be obtained even when the adhesive coating is covered by the above-mentioned intermediate

coating when the latter is of a kind that is permeable to the cross-linking agent contained in the foam-forming mixture. Although permeable to the cross-linking agent, the intermediate coating can still serve a barrier function by preventing other substances from migrating from the foam to the adhesive and adversely affecting its properties and its releasable relationship to the liner sheet.

Process allows tacky product on surface! More cohesive near core

Since curing of the adhesive polymer reduces its solubility, and may in fact render it highly insoluble in common solvents, this technique circumvents problems connected with curing the adhesive at an earlier stage. It also results in the adhesive coatings of the foam-layer product having been cured from the inside out, so that each adhesive coating will have maximum tackiness on its functional face surface and maximum cohesiveness in the interior, the cohesiveness increasing toward the underlying skin layer of the product structure.

Polyurethane Foam

The preparation of preferred polyurethane foams is described in U. S. patent No. 2,921,916. The viscous foam-producing batter mixture that is sandwiched between the liner webs pursuant to the foregoing manufacturing system, may consist essentially of a mixture of polyurethane prepolymer, water and a catalyst, together with a flame retardant agent if desired. The prepolymer may be formed from an alkyd resin of castor oil and diglycollic acid which is reacted with tolylene diisocyanate or the like to provide a partially polymerized polyurethane. The water acts as the reactive foam generating agent. The mixture is promptly extruded from the mixing machine and deposited upon the lower liner web as a layer upon which the upper liner web is laid, the resulting sandwich passing between spaced-apart squeezing rolls that are adjusted to provide a uniform wet layer of desired thickness. Free foaming of this layer between the flat supporting and covering liner webs (which are under tension) occurs, together with further polymerization of the polyurethane,

as the webs are drawn through a heating zone to provide a relatively thick and low-density foam layer. Upon leaving the heating zone, this warm and incompletely polymerized layer is gradually compressed between the webs to a relatively high bulk density foam layer having the desired ultimate thickness. Sufficient time is permitted thereafter for the polymerization reaction to be essentially completed so as to result in a stable cured foam layer whose surface skins are integrally united to the adhesive coatings carried by the liner webs. The product is then cooled and is ready for further handling in converting to rolls of the adhesive tape product shown in the drawing.

During this process, using the type of polyurethane foam-forming mixture indicated above, a polyfunctional cross-linking agent is provided by the foam layer mixture, believed to be unreacted diisocyanate compound that is present, which migrates in part into the pressure-sensitive adhesive coatings and is available for curing the latter. Such migration can occur even though the adhesive coating is covered by an intermediate coating (for example, a thin butadiene-styrene copolymer coating).

The presently preferred pressure-sensitive adhesives are viscoelastic cross-linked polyacrylates which inherently are aggressively-tacky and highly cohesive; the polyacrylate being a copolymer of an alkyl acrylate having an average of 6 to 12 carbon atoms in the alkyl group and a small proportion (about 3 to 12%) of a copolymerizable monomer having a strongly polar functional group (such as acrylic acid, methacrylic acid, itaconic acid, acrylamide, methacrylamide, acrylonitrile, methacrylonitrile, or mixture thereof). A 90:10 copolymer of isooctyl acrylate and acrylic acid is exemplary. These copolymers are described in U. S. patents Re. 24,906 and No. 3,008,850. Internal cohesive strength and shear strength can be increased by cross-linking curing as described in U. S. patents Nos. 2,925,174 and 2,973,286. This type of adhesive has the advantage in the just described

Acrylic PSA (early patents)

→ Curing of PSA's

manufacturing procedure that cross-linking and curing can be effectuated during manufacture of the foam-layer product, utilizing a cross-linking agent provided by the foam layer mixture.

Referring again to the physical properties of the foam-layer adhesive tape product, which are responsible for its previously indicated utility as a mounting tape:

The soft "lossy" viscoelastic cellular foam layer, which has a relatively high density, should have a dynamic storage shear modulus (G') in the range of 10^6 to 10^8 dynes per sq. cm. and a loss tangent value (Beta) in the range of 0.3 to 1.5, as measured at room temperature at a vibration frequency of 600 cycles per second. The samples to be tested are sliced from the foam layer of the adhesive tape product. The determination of these values is well understood in the acoustic and vibration fields and need not be described here.

X Dynamic Shear Modulus desired.

The skin and adhesive layers of the tape structure are extremely thin and are of a viscoelastic stretchy nature so that the viscoelastic conformability and compressibility properties of the tape, contributed by the foam layer, are effectively utilized. It is necessary that the tape have an elastic compressibility modulus within a certain range since otherwise it will be too soft and stretchy (and hence too weak and too prone to sag), or will be too firm and insufficiently conformable. We have found that these requirements are satisfied when the adhesive tape has a compressibility modulus within the range of approximately 6 to 30 pounds per square inch (0.4 to 2.1 kgs. per sq. cm.) at 20% compression. This modulus is measured by cutting 1 inch by 1 inch (2.54 cm. by 2.54 cm.) squares of tape and stacking to form an approximately cubical block (having a thickness of approximately 1 inch (2.5 cm.)). This block is then compressed between platens (in a direction perpendicular to the plies) and the force necessary to produce a 20% compression (which is also the force needed to balance the elastic recovery

X Elastic component

X

force exerted by the compressed tapes) is measured. The force per unit area is the elastic "compressibility modulus" value to which reference is made herein.

The hyper shear strength value of a pressure-sensitive adhesive coating of the tape product is demonstrated and measured as follows: The liner is removed from one side of a suitable piece of the tape, as by taking the tape from a roll. The exposed adhesive coating with its underlying skin layer is peeled away and the foam layer is removed by slicing and scraping with a razor blade, leaving the other skin layer and adhesive coating attached to the supporting liner. A gummed paper tape is bonded to the surface of the exposed skin layer to provide reinforcement and planar rigidity and, after drying, the sample is conditioned by exposure to the atmosphere at approximately 22°C. and 50% relative humidity for at least 16 hours, and the test is performed under these conditions. A test strip 1/2 inch (1.27 cm.) wide and approximately six inches (15 cm.) long is cut. Use is made of a clean stainless steel rigid test panel having a straight bottom edge milled to form an angle of 90° with the flat surface of the panel. The test strip is applied to this panel (supported in horizontal position) so that a 1/2-inch by 1/2-inch (1.27 cm. by 1.27 cm.) end area is in pressure-sensitive adhesive contact, contiguous to the edge and perpendicular thereto. The strip is firmly pressed against the horizontal panel by means of four passes with a rubber-covered roller weighing 4.5 pounds (2 kgs.). The test panel is then clamped in a vertical position so that the free end of the test strip hangs from the horizontal bottom edge. This free end is folded over on itself, adhesive side in, to form a loop, and a 1000 gram weight is hung therefrom. Measurement is made of the time interval between application and falling of the weight, the weight falling when the sample has slipped from the test panel due, usually, to shear splitting of the adhesive layer. The time in minutes is the "shear strength value". A

representative average value is calculated based on the data for at least four samples. The longer the time the greater the shear strength of the pressure-sensitive adhesive coating in contact with the polished surface of the test panel.

1/2"x1/2"x 1000gm
↓
500 minutes
min

The shear strength value of the pressure-sensitive adhesive coatings of the present tape product should be at least approximately 500 minutes (as above defined).

The foregoing type of test demonstrates the hyper shear strength of the pressure-sensitive adhesive coating itself. A different bonding strength adhesion value test is needed for measuring performance characteristics of the double-coated foam-layer tape when used as a mounting tape and subjected to a dead gravity load which may cause failure either due to inadequate shear strength of the adhesive or due to peeling of the tape. An adhesive coating may have a sufficiently high shear strength and yet permit the tape to peel down from the vertical surface to which it is adhered. The adhesive coatings are subjected to forces under this tape usage condition which differ from the force relationships involved in the above adhesive shear test, owing to the stretchy nature and thickness of the foam layer structure to which the adhesive coatings are united. The following laboratory test procedure has been developed upon the basis of a great deal of testing experience:

Method of testing

A rectangular aluminum plate (4 inches by 8 inches) (10 cm. by 20 cm.) is used, having a polished flat shiny-smooth face surface to provide a standard test surface free from complications that would result from using a rough or uneven surface. A straight bottom edge (having the longer dimension) is milled to form an angle of 90° to the face of the plate.

A weighted aluminum testing block simulating a mounted article is also used, made of a 1 inch by 1 inch (2.54 cm. by 2.54 cm.) square block which is 1/2 inch (1.27 cm.) thick, the edges being milled to be at an angle of 90° to the face which is

a polished shiny-smooth flat surface. A small hook (for supporting the weight) is secured to the bottom edge, equidistant from the sides, but off-centered by 1/8 inch (3.2 mm.) so as to be nearer the face side than the back side of the block. The face surfaces of the plate and block are cleaned just before use by first polishing with a fine abrasive cloth to remove surface imperfections, followed by washing with methyl ethyl ketone solvent and drying.

The liner-protected adhesive tape is conditioned before testing by exposure to the atmosphere at approximately 22°C. and 50% relative humidity for at least 16 hours, and the test is performed under these conditions.

A tape sample larger than the block is used. Carrying a liner on one side, the exposed tacky side is contacted with the face of the test block, the sample being applied with a rolling motion to insure intimate contact and prevent air entrapment. The sample is then trimmed with a razor blade to the precise size of the block. The liner is removed and the test block is positioned, using a rolling motion, upon the face of the plate (now supported in horizontal position upon a table) so that the hook-carrying bottom edge is in alignment with the bottom edge of the plate. A 1000 gram weight is placed upon the horizontal back of the test block for 15 minutes to exert a controlled pressing action and to assure intimate contact between the two adhesive coatings and the aluminum surfaces. The plate is then mounted in a vertical position and a 2000 gram weight is hung from the hook at the bottom of the block. The square sample of foam-layer adhesive tape is thus suspended between and adhered to the plate and the block, the latter being loaded by the suspended weight and tending to drag the tape sample downward on and past the plate surface.

The time interval between the hanging of the weight and the dropping of the block, measured in hours, is the "bonding

strength adhesion value" referred to herein. This value should be at least 30 hours, and preferably at least 50 hours.

It will be noted that under these test conditions the mounted tape sample carries a load (due both to the weight of the aluminum block and to the suspended weight) which is much greater per unit area of the tape than is involved in the actual mounting usages previously mentioned, and that the tape is in contact with smooth flat aluminum surfaces. An accelerated type of test is obviously necessary. Experience indicates that a mounting tape having a bonding strength adhesion value of at least 30 hours, as thus determined, should assure a durable mounting function under normal conditions of usage. The foam layer of the tape must have sufficient shear strength to avoid foam-layer failure during the minimum 30 hours period, and hence compliance with this test serves also as a demonstration of foam layer strength.

Criteria for Success

Example

This example provides further details on the manufacture of presently preferred adhesive tape products made by the previously-described continuous procedure wherein the foam layer is formed between liner sheet webs precoated with pressure-sensitive adhesive.

The bottom liner sheet web (which provides the liner in the ultimate wound roll product) is a dense supercalendered paper coated on both sides with a release coating of heat-cured anti-stick silicone resin (such as Dow-Corning's "Syl-off 23"). The face side carries a pressure-sensitive adhesive coating of a rubbery viscoelastic aggressively-tacky copolymer of isooctyl acrylate and acrylic acid (90:10 weight ratio), in a dry coating weight of approximately 110 lbs. per thousand square yards (60 kgs. per thousand square meters), the dry thickness being in the range of 2 to 3 mils (50 to 75 microns). This adhesive coating is covered by a nontacky coating of a butadiene-styrene copolymer (33:67 weight ratio) (such as Goodyear's "Pliolite 160"), in a

dry coating weight of approximately 35 lbs. per thousand square yards (19 kgs. per thousand square meters), the dry thickness being approximately 1 mil (25 microns). The top liner sheet web is the same except that there is no need of a release coating on the back, since this liner serves a temporary use and is ultimately removed.

The two liner webs are continuously drawn from supply rolls and pass around guide rolls to enter the making machine under tension in horizontal spaced-apart relation, the adhesive-carrying sides facing each other, the lower web being supported by flat bed plates as it is drawn through the machine. These guide rolls are adjustable so that the spacing distance at the nip can be controlled to provide the desired coating thickness of the viscous foam-forming mixture which is extruded upon the face of the bottom web just ahead of the nip.

This foam-forming mixture is prepared using the teachings of U. S. patent No. 2,921,916. PU Early foam mixture patent A polyurethane prepolymer is made by first preparing an alkyd resin of castor oil and diglycollic acid (12.3:1 weight ratio) having an acid number in the range of 4 to 5. This is mixed and reacted with tolylene diisocyanate (for example, du Pont's "Hylene TM") in 2.52:1 weight ratio; the reaction being conducted at 150-200°C. for a length of time sufficient to form a prepolymer having a viscosity of 10,000 to 25,000 centiposes at 25°C. as measured with a Brookfield viscometer. A mixture is then made of 100 parts by weight of this polyurethane prepolymer and 1 part of dimethyl polysiloxane anti-foaming additive (for example, Dow-Corning's No. 200 fluid) and 0.2 part of stannous octoate (for example, Nuodex's "Nuo-Cure No. 28"). The function of the silicone additive is to control the subsequent foaming action to provide a finished foam layer product having a relatively uniform fine-celled structure. The stannous octoate promotes the action of the subsequently added catalyst.

The foam-forming mixture is continuously prepared at the appropriate rate in a mixing head extruder located above the head of the machine into which the webs are drawn as above noted. To each 100 parts of the prepolymer mixture are added 4.5 parts of a premixed solution of water and diethyl ethanolamine in 3:1 weight ratio. The water acts as the reactive foam generating agent and the amine serves as a catalyst.

This foam-forming mixture is continuously extruded upon the advancing bottom liner web at a rate to provide a layer thickness of approximately 30 mils (0.76 mm.) in making a product having a finished foam-layer thickness of 1/8 inch (3.2 mm.) and bulk density of 14 lbs. per cubic foot (0.22 grams per cc.), and the following description specifically relates to such product. Other products within the scope of the invention can be similarly manufactured with such adjustments of operating conditions as are appropriate.

4times

The advancing webs, with the foam-forming layer sandwiched between them, travel at a rate of 22 ft. (6.7 meters) per minute, and move through a horizontal oven about 53 feet (16 meters) long. Heating is supplied by radiant heating panels located above and below the web; these being heated by circulating hot water (at about 90°C.); the air temperature as measured 2 inches (5 cm.) above the web reaching about 65°C. During this stage of travel, free foaming occurs between the supporting web and the unrestrained covering web (which rises as the foam layer expands) to produce a "green" low density foam layer about 1 1/4 inch (32 mm.) thick. As previously explained, this foaming against the intermediate coating which covers the pressure-sensitive adhesive results in strong bonding and also permits unreacted diisocyanate to migrate into the acrylate polymer adhesive and produce cross-linking. The warm foam-containing web then leaves the oven and moves on the bed plate through room air for about 12 feet (4 meters) during which stage it is gradually

Process

compressed by 10 rollers which are progressively more closely spaced to the bed plate, and then by passing between power-assisted caliper setting rolls, to result in the final foam-layer thickness of 1/8 inch (3.2 mm.) and desired high bulk density. Polymerization continues during this stage.

The warm product then travels a further distance of about 30 feet (9 meters) in room air to permit of essentially completing the polymerization or curing of the foam layer; and the cross-linking of the pressure-sensitive adhesive coatings is also advanced. The product then passes through a chilling unit cooled by solid-CO_2 (or equivalent mechanical refrigeration) where it is cooled to near room temperature and the top liner is chilled sufficiently to permit of easy stripping off. Then the product passes through the nip between driven rubber-covered pull rolls which pull the sheeting under tension through the entire machine and control the speed. The nip spacing is such that the cured foam layer is momentarily squeezed under tension to about 50% of its normal thickness and then springs back. This action opens up the cell structure and stabilizes the foam layer so that subsequent shrinkage or collapse is prevented. The temporary top liner is then peeled off and wound up on a driven liner winder. The double-coated foam layer and the adhering bottom liner are wound up in a jumbo roll. Further curing of the foam layer and cross-linking of the adhesive may take place in the product. In a later operation this sheeting is slit and wound into tape rolls of desired width and length, ready for packaging and sale. (See Fig. 1).

1° How to prevent collapse of foam structure

This procedure results in a viscoelastic spongy polyurethane foam layer having a fine-textured predominately open-cell structure that is somewhat fibrous, the cavities or interstices randomly varying in size from about 50 to 500 microns; the surface "skin" of each face thereof being smooth but extremely thin and not being an impermeable membrane, since the contiguous

open-cell urethane structure

size of cells

surface cavities are not completely closed over, as is evident upon microscopic examination. The foam layer surfaces are united to the intermediate coatings and together provide unitary composite skin coverings which support and retain the overlying pressure-sensitive adhesive coatings. Each composite skin element has a thickness of about 1.5 mils (35 microns), which may range in practice from about 1 to 3 mils (25 to 75 microns). These viscoelastic skins and adhesive coatings can stretch at least 200% before rupturing.

The combination provides a tape which can adapt itself to any roughness or irregularity of the article or wall against which it is pressed to secure maximum intimate adhesive contact. The area of the tape surface increases upon such contacting, this being permitted by the stretchy nature of the material, so that the actual pressure-sensitive adhesive contact area is materially greater than the area of a corresponding flat surface. This increases the effective holding power of the tape. The viscous or "lossy" nature of the tape structure resists retraction and pulling away. Roughness or porosity of the contacted article or wall surface also enhances the durability of the mounted relationship because of a certain degree of mechanical interlocking that develops; and there is greater resistance to interfacial slipping and shear.

In typical tape products made in the above manner, having a foam layer thickness of 1/8 inch (3.2 mm.), the following representative average values were determined for the mentioned physical characteristics:

The longitudinal tensile strength was 10 lbs. (4.5 kgs.) for tape having a width of 1 inch (2.54 cm.) as tested in a tensile tester with an initial jaw separation of 4 inches (10.2 cm.), the jaws separating at the rate of 12 inches (30.5 cm.) per minute. This is the tensile value reached when incipient rupture occurs, at the peak of the stress-strain curve, the corresponding

elongation value being 60%. The normal tensile strength value (measured perpendicularly to the plane of the tape) was 19 lbs. per square inch (corresponding to 1.3 kgs. per sq. cm.); a 1 inch by 1 inch (2.54 cm. by 2.54 cm.) square sample of tape being adhered between two platens which were then separated at the rate of 0.2 in. (0.51 cm.) per minute. The longitudinal peel strength of the foam layer was 1.25 lbs. (0.57 kg.) for a tape having a width of 0.5 in. (1.27 cm.); determined by mounting the tape on a flat bed plate, splitting the foam layer at one end, pulling back the upper half-layer of the tape at a 180° angle and connecting to a force measuring device, and then uniformly advancing the bed plate at the rate of 90 inches (229 cm.) per minute; thereby measuring the force required to continue the splitting of the foam layer under peeling conditions.

The storage shear modulus value of the foam layer was 1.74×10^7 dynes per sq. cm., and the loss tangent value was 0.35, both measured at room temperature at a vibration frequency of 600 cycles per second. The tape had a "compressibility modulus" value of 10.7 lbs. per square inch (0.75 kg. per sq. cm.) at 20% compression.

The "shear strength value" of the pressure-sensitive adhesive coating was about 700 minutes, even though the thickness is about double the value for conventional film-backed tapes. (Use is made of a thicker than normal coating in the present tape product in order to obtain better bonding to porous and rough surfaces.) The "bonding strength adhesion value" of the adhesive tape was 70 hours; failure occurring due to splitting (shearing) of the adhesive.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

Claims

1. A double-coated foam-layer pressure-sensitive adhesive mounting tape article of the character described, comprising an adhesive tape having a soft viscoelastic foam layer that is approximately 1/16 to 1/4 inch (1.6 to 6.4 mm.) thick and is continuously covered on each side by a thin stretchy integral flat-surfaced skin to which is united a continuous flat shiny-smooth viscoelastic aggressivley-tacky pressure-sensitive adhesive coating, and a removable liner covering each face of the adhesive tape and providing a shiny-smooth release surface in continuous adherent contact therewith; said adhesive tape having a compressibility modulus of approximately 6 to 30 pounds per square inch (0.4 to 2.1 kgs. per sq. cm.) at 20% compression, and said foam layer having a storage shear modulus in the range of 10^6 to 10^8 dynes per sq. cm. and a loss tangent value in the range of 0.3 to 1.5 (both measured at 600 cycles per second); the pressure-sensitive adhesive coatings having a permanent hyper shear strength and essentially consisting of a water-insoluble non-softening aggressively-tacky viscoelastic cross-linked polymer, such that they impart to the tape a bonding strength adhesion value of at least 30 hours (as herein defined); the combination of physical structure properties of the adhesive tape being such that rigid weighty articles can be mounted even on rough wall surfaces by merely pressing strips of the pressure-sensitive tape on the back of such an article and then pressing the article in position against the wall to thereby provide a durable resilient semi-rigid mounting of the article.

2. A tape article according to claim 1 wherein a polyurethane foam layer is used having a bulk density of approximately 12 to 16 lbs. per cubic foot (0.19 to 0.26 grams per cc.); the pressure-sensitive adhesive coatings have a thickness in the

range of approximately 2 to 3 mils (50 to 75 microns) and consist essentially of a cross-linked copolymer of an alkyl acrylate having an average of 6 to 12 carbon atoms in the alkyl group and a small proportion of a copolymerizable monomer having a strongly polar functional group; and the tape has a bonding strength adhesion value of at least 50 hours.

*

CANADA 747341

PRESSURE-SENSITIVE ADHESIVE TAPE

FIG. 1

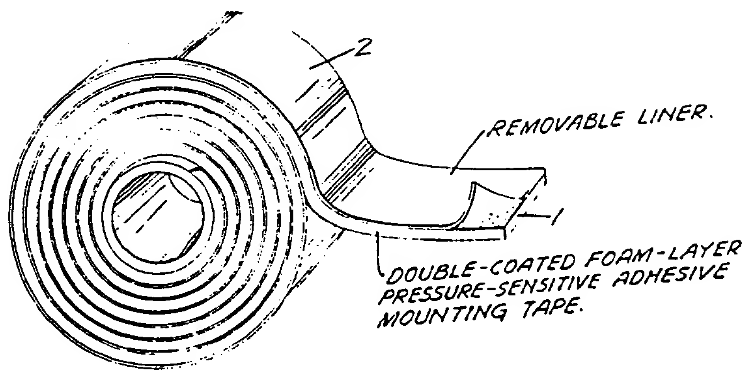

FIG. 2